

**THE USE OF HYPERMEDIA
TO INCREASE THE PRODUCTIVITY
OF SOFTWARE DEVELOPMENT TEAMS**

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ABSTRACT

Rapid progress in low-cost commercial PC-class multimedia workstation technology will potentially have a dramatic impact on the productivity of distributed work groups of 50-100 software developers. Hypermedia/multimedia involves the seamless integration in a Graphical User Interface (GUI) of a wide variety of data structures, including high-resolution graphics, maps, images, voice, and full-motion video. Hypermedia will normally require the manipulation of large dynamic files for which relational data base technology and SQL servers are essential. This paper will cover basic machine architecture, special-purpose video boards, video equipment, optical memory, software needed for animation, network technology, and the anticipated increase in productivity that will result from the introduction of hypermedia technology. It is suggested that the cost of the hardware and software to support an individual multimedia workstation will be on the order of \$10,000.

INTRODUCTION

Extrapolating the ten-year history of PC-class personal computing, we can forecast that the next decade will witness progress at an accelerating pace. By the year 2001 we can expect to buy a "4G" workstation [where the "G" stands for "giga" as in 1 GIPS, 1 GB RAM, 1 Gpixel (30K)², 1 Gbit/sec BW] for about the same price as we pay for an ordinary PC today. What will we be doing with such a supercomputer on our desktop? Obviously, we will be solving problems for which this sort of power will be taken for granted in the same way that no one would ever return to a conventional typewriter and carbon paper after using a PC word processor plus copy machine to get routine work done in the same way that practitioners of the old typewriter technology would never go back to using ink quills and parchment for written communications commonplace in the time of their predecessors.

The key to improved productivity in the next Century will depend on hypermedia. By definition, hypermedia is the seamless integration in a GUI (Graphical User Interface) or Windowing Environment of a variety of data structures, including: numbers, text, mouse-clickable icons, 3-D bit-mapped color graphics (charts, graphs, etc.), animation, maps, high-resolution images (e.g., Landsat Images), voice, music, full-motion video, and what has now come to be called "virtual reality." Each level of detail in a complex representation of an information structure will be "mouse clickable" up to the maximum level of resolution possible in whatever manner the user wishes to access it. Sometimes a cursory level or abstraction is adequate for understanding and extra detail would only clutter the landscape, while at other times the maximum level of detail is indispensable for understanding. Since the author of a complex information structure cannot anticipate the needs of each user, the information must be presented at the highest level of abstraction in such a manner that the user has the option to interactively "mouse click" his way into the supporting data as he sees fit. Hypermedia may not be ideal for all forms of communication. For example, a literary novel is essentially a flat data structure (with the exception of occasional chapter headings). However, the design, construction, and operation of an advanced spacecraft is a multi-hierarchical activity to which a user cannot usefully contribute without the selective access to an extraordinary array of detail. Compression of detail with selective accessibility when needed by using hypermedia would be an ideal way for an engineer to come up to speed quickly on a large body of information.

Thus, hypermedia will involve the transparent manipulation of large distributed data bases that must be updated regularly, if not in real time (e.g., telemetry). Such updates may also involve uncertain or even contradictory data derived from disparate sensory modalities.

To achieve the feeling of presence, a team of 50-100 software developers, working in different parts of the world (in different time zones), not only need to be able to transmit reusable object-oriented programs to one another over a common network as they do now; they must also have the ability to transmit e-mail messages containing mouse-clickable icons of short bursts of full-motion video that show how a program actually behaves during operation together with mouse clickable icons of digitized voice annotation commenting on these programs. Remote debugging of jointly developed code through a combination of e-mail, remote login, and telephone communication does not always provide the sensation of presence needed to expedite the process of debugging. Using today's technology the process of debugging when the author of a program is physically present vs. interacting on the telephone can be an order of magnitude faster. In the future using hypermedia and desktop teleconferencing over ISDN telephone lines, the requirement for physical presence will be completely obviated. Furthermore, the best members of a software team can be rapidly assembled to carry out a short development task or form a "tiger team" to debug a problem during a crisis, regardless of geography. Indeed, at a more distant future time telepresence will eliminate the need for commuting to one's job, and one could conceivably live in any location one desired.

Other applications for hypermedia technology include the rapid creation of S-VHS video tapes (not broadcast quality) for executive presentations, ordinary briefings, and training. Indeed, one of the major untapped areas for this technology is in education. The only thing educators are waiting for is for the cost of the technology to come down sufficiently to justify it as a viable alternative, which will certainly happen in the next few years.

YOUR OWN MULTIMEDIA/HYPERMEDIA WORKSTATION

In this section we will provide our "recommended list" for the acquisition of parts and assembly of a standard multimedia workstation. This includes the following topics: basic machine architecture, special-purpose boards to handle full-motion video, commercial video equipment, optical memory, animation software, networking, information retrieval from large data bases, integrating sound, and integration and interoperability.

Basic Machine Architecture

The choices include various PC clones (DOS), Apple Macintosh (System 7), Amiga, IBM PS/2 (OS/2), and Compaq 386/33Mhz or 486. The estimated cost for such a PC clone is in the neighborhood of \$4K. More expensive workstations are also suitable if one already has such a machine that can be dedicated to this function. These include engineering workstations such as Sun Sparc, DEC Station (MIPS), HP 7000, IBM 6000, Motorola 88000, NeXT, or even a special-purpose graphics workstation like a Stardent or a Silicon Graphics.

Recommended examples of standard PC Options are as follows: 8MB of RAM Memory plus 100 MB or more of hard drive; an NEC MultiSync 4D or better high-resolution color monitor; a super-VGA Graphics board such as Video Seven VRAM-II; a Hayes-compatible modem; a Western Digital ethernet board, a two-button mouse (cordless); dual floppy drives (3 1/2" and 5 1/4"); enhanced keyboard (101 keys); one parallel and two serial ports; DOS 5.0 and Microsoft Windows 3.0. A math co-processor is optional. Access to a Laser Printer is assumed.

Special-Purpose Boards

A frame grabber or image capture board is essential (Super Via from Jovian Logic for PCs or VideoPix for Sun SparcStations). A scan-converter board, such as the VGA Producer from Magni Systems, is needed to convert RGB graphics to NTSC television format. This provides a capability for graphic overlays, like icons positioned on a map. A full-motion video in a window board, such as Super Video Windows from New Media Graphics, is needed. This allows any video source (Live Camcorder, Over-the-air or Cable, VCR, or Laser Disk)

as input in a fully-scalable, movable window. An audio card like the SoundBlasterPro for output or IntroVoice VI for input is also useful. The estimated cost of these boards is about \$2K. Optional cards include a FAX board (FAXPRO) or a VCR Controller (Diaquest), but they do tend to bring up the price.

Other useful display options include an LCD flat-plate color projection screen for an audience of 5 to 30 persons, a color hardcopy printer, and a scanner (for example, the HP Scan Jet flatbed scanner with accompanying OCR software and/or the A4 hand-held color scanner) are useful. In 1993 Intel plans to introduce its DVI chip set for video compression (temporal and spacial) and this will represent a significant compression in bandwidth needed to send video images over leased phone lines.

Consumer Electronics Video Equipment

A high-resolution color monitor, a Hi8 camcorder (Canon) and tripod, two s-VHS VCRs (capable of independent control of luminance and chroma levels), a Laser Disk Player (Pioneer 4200), and two active stereo speakers (Sony bookshelf @ 30 watts each) are the minimum needed to get started. The estimated price is \$2K. Optional VHS editing decks, such as from Sony or Panasonic, are needed to handle complex animation sequences and will simplify the video editing task.

Flat screen, 50" on a side, wall-mounted HDTV displays will come by the end of the century. Preliminary HDTV laser-disk experiments at consumer electronics shows proves that their quality will be as good as film.

Optical Memory

A CD-ROM player attachment for your PC can now be bought for under \$500. Many publishers are now considering this as the medium of choice for periodicals, images, reference works (encyclopedias, dictionaries, atlases, classical literature, etc.), and now even software (operating systems and third-party applications are now distributed on CD-ROM).

Sectorized erasable magneto-optical media storing 640 MB of data per cartridge (\$120 each) are now routinely available and are rapidly making WORM (Write Once Read Many) media obsolete. The optical density of these cartridges is soon expected to be doubled. Furthermore, the creation of jukebox technology through a SCSI interface at reasonable prices (a 10-platter model from IDE gives a total of 6.4 GB for about \$10K while a 144-platter model from HP gives a total of 120 GB for about \$80K) gives a cost per bit of storage at reasonable access times that can't be beat by hard drive technology.

Animation Software

The choice of operating system (DOS 5.0, UNIX, OS-2, or System-7) is dictated largely by the vendor of the hardware platform. However, as soon as a standard version of UNIX becomes more popular at the PC (Solaris 2.0, LAN Workplace) and MAC level in the next few years, this will be increasingly less so. A windows environment (Windows 3.0 or Microsoft New Technology [NT] Operating Environment, SunView, X-Windows [OpenLook 2.0, Motif, X-Vision, DeskViewX]) is needed to support a mouse for "point-and-click" and "drag-and-drop" operations. In addition, standard development tools (Omnis-5, SuperBase-IV, TookBook, VisualBasic) and standard applications for word processing/desktop publishing/office automation (Frame, Microsoft Word, WordPerfect), spread sheet (Lotus 123, Excel), project management (Primavera, Project), Expert System Shell (Kappa, ART), and relational database systems (FoxPro, Oracle, Sybase) will be needed. The cost of these packages is not included, since it is assumed that one would be buying these anyway.

However, a number of commercial software packages have been created to facilitate the overlay of animated 3-D graphics on full-motion video integrated with sound (voice narration/music), including GRASP 4.0 from Paul Mace Software, SantaFe Media Manager from HSC Software, MacroMind Director, 3-D Studio from AutoDesk, and the Video Toaster from NewTek, Inc. (special effect library). These packages have stretched the English language with their own new vocabularies (e.g., masking, keying, embossing, posterization,

mosaicing, pixelation, voxelation (volumetric pixel), chiseling, texture operators, transparency/translucency/opacity/specularity/gloss/matte/diffuse, shading (Phong/Gouraud), "lofting" (extrusion), morphological operators (erosion/dilatation), "tweening", "morphing" (3-D), sparkle wipe, fade, dissolve, shrink-and-tumble, etc.). The estimated cost for this software is \$1.5K.

To my knowledge, no software package is yet available that addresses the need of amateur video producers to compute automatically the number of video frames required to cover a spoken sound-byte (previously recorded with a known duration in milliseconds of digitized speech) so that it can be spliced in (drag and drop) at the click of a mouse. Conversely, visually sliding a music clip over a certain number of frames with the proper fade in/out characteristics mixed in with voice narration would be a substantial productivity boon for the home video editor.

Networking

Client/Server architecture is increasingly popular in Local Area Network design, since it distributes computing cycles appropriately over a network. Network communication packages (such as Novell 386, Banyan Vines, LAN Manager, PC Plus, CrossTalk) and e-mail (DaVinci) are needed to manage network administration. However, for nationwide workgroup conferencing the DARPA Net (with TCP/IP and ethernet protocols) is inadequate. What is needed in addition is desktop video teleconferencing at standard voice telephone-line rates. Video teleconferencing is currently achieved today using expensive T1-class satellite links (\$650/hour for 1544 Kbits/sec broadcast-quality bandwidth) and expensive codec devices to digitize the analog video signals at each end (est. \$70K each). The possibility of using leased ISDN high-quality telephone lines (128 Kbits/sec) with (\$2K codecs and Data Terminal Adaptors [DTAs] under a synchronous v.35 protocol) will revolutionize telecommunications in the next few years and radically change our transportation/communication tradeoffs. SMDS (Switched MultiMegabit Data Services) and Broadband ISDN (2.5 GB/sec using fiber optic cable) are expected by 1995.

The software needed to facilitate these kinds of multiperson desktop teleconferencing-in-a-window environments doesn't exist yet. BBN Slate is a close approximation in so far as multimedia e-mail capabilities are concerned, but it runs only on UNIX machines at present. A nice feature of Slate is its ability to place automatically a digitized voice-annotation clip under an icon embedded at an appropriate point in the text of a larger document. So, for example, if the recipient of a Slate document sees such an icon in the text and clicks on it, he may see a pop-up stating that "so and so" recorded 12 seconds of speech at "such-and-such" a time on "this-or-that" date. "Do you want to hear it?" Another click and he will then hear the sound clip through a speaker attached to his machine. This method of intermixing voicemail narration into the text of document can enormously speed productivity for busy decision-makers.

Large Data Bases

FoxPro in the PC environment or Sybase, Oracle, or Informix in the UNIX environment are good choices for developing data base applications. Distributed data bases over several network servers will become commonplace in the future. Compuserve and other information retrieval services are just starting a major expansion, as home PCs become more popular. Rumba from Wall Data, Extra! from Attachmate Corp., and Select from DCA are macro retrieval packages to facilitate PC to Mainframe database communications. Data integrity (UPS) and security are important issues. DES encryption boards from Centel, Inc. and SmartID cards for user password authentication from Security Dynamics address some of these issues.

Sound

Speech and music will both play an increasingly important role in software development in the future. Reasonably intelligible speech synthesis (text to speech) by hardware (SoundBlaster Board) or Software (Monolog 2.0) can be incorporated inexpensively into any software application to provide warnings or error messages or for whatever purpose. Speech input from the user, however, is much more difficult. The Introvoice VI board, for example, at a price of over \$1000 is vocabulary limited (500-1000 words or phrases) to isolated

(noncontinuous) speech, speaker dependent, limited by having to endure an extensive training session, and is still unreliable in a noisy environment. Nevertheless, for certain applications it is quite respectable. Sphinx from Carnegie-Mellon University is a step toward reliable, continuous speech, but is still experimental and not yet incorporated into a commercial product. Music and the mixing of multichannel audio sources (drag-and-drop icons of sound effects into the middle of a production) is extremely difficult to do well. This challenge frequently distinguishes a high-quality production from an off-shore or low-budget production even in professional environments where the video portion is impeccable. Achieving dolby surroundsound quality in amateur productions is still some years away. Achieving the acoustics of an anechoic chamber, an intimate room, a conference room, a concert hall, a cathedral, a football field, etc. should someday be done at the click of a mouse.

Integration and Interoperability

DDE (Dynamic Data Exchange) or Hot Links between multiple applications running within the same window environment or across multiple platforms through a network is one of the most challenging aspects of work group conferencing. Remember that it was not too long ago that even tape formats were incompatible across vendor boundaries because open systems had not yet been advocated by the leaders of the industry. Standards were slowly incorporated through the diligence of government sponsors and disinterested professional societies. Just as all electrical appliances must be compatible with certain power distribution parameters (frequency, voltage, etc.) within national borders but are usually incompatible across continental barriers where different arbitrary standards were adopted, all computing cycles should also be "vanilla" flavored. Obviously, there are many more degrees of freedom in the parameterization of computing interfaces than there are in electric power distribution, but we are correspondingly more immature in our development of computing standards and this should be ameliorated in the coming decade. Differing man-machine interface standards for something as seemingly simple as "mouse clicking" in different applications on the same platform have been known to result in "acute brain meltdown" for some of our users. In our opinion, the recent trend toward consortia among industry leaders will facilitate this process of standardization and open computing.

The EASL (End user Applications Software development Laboratory) Laboratory at JPL (Figure 1) was created to test the interoperability of software across a number of the popular hardware platforms (DEC, HP, Sun, IBM, and Apple). EASL is less interested in benchmarking algorithms on different machines to measure performance than it is in verifying the operability of commercial software applications within the JPL network environment before major software acquisitions are finalized.

PRODUCTIVITY ENHANCEMENT

As a single testimonial, Micromedia Development Corp. is a software developer and audio/video supplier located in Vancouver, British Columbia that now uses video tutorials to replace written manuals for their systems. "We used to be inundated with technical support calls," said Roland Haynes. "With video tutorials, our calls have been reduced by 80 percent because we can compress a 400-to-500 page manual into a 30-minute video, which is even more effective." According to Haynes, "I would estimate that we have saved about \$35,000 this year because three people can now support a work load that previously required eight or nine people."

SUMMARY

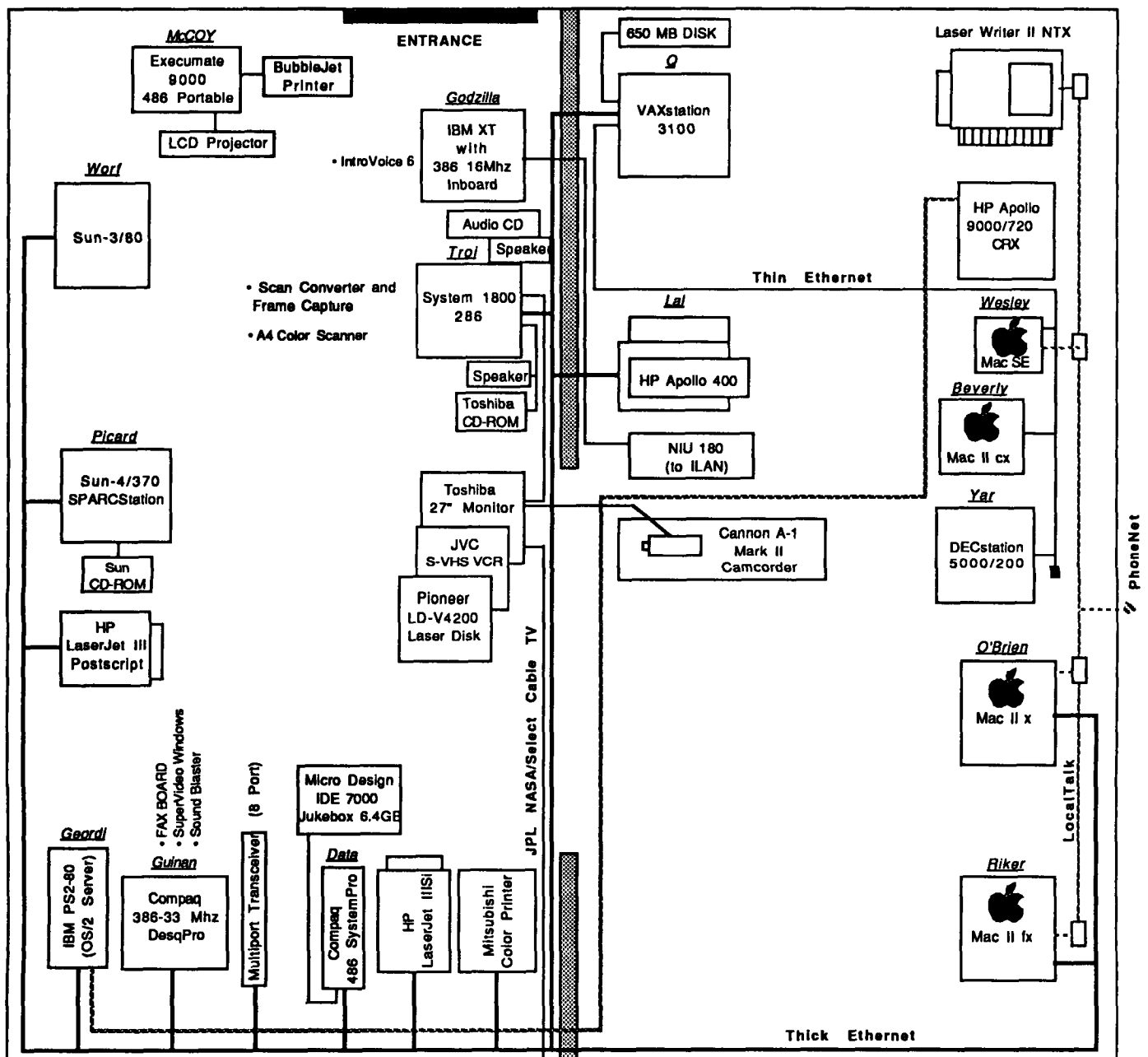
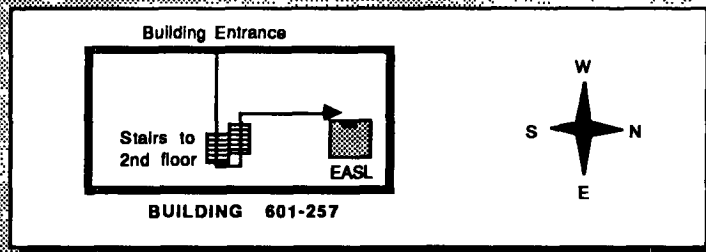
In today's market-driven world, multimillion-dollar 30-second TV commercials and longer video productions are crafted by teams of highly paid professionals. This price of admission is, of course, a major "barrier to entry" for ordinary folks. In the future, through the use of low-cost hypermedia-presentation technology, the production of high-quality targeted video presentations will no longer be limited by the thickness of one's pocketbook; relatively speaking, your capacity to communicate, to educate, and to persuade will only be limited by your imagination. In our view, as teams of software developers using this technology begin to interactively debug large complex systems, independently of geographic boundaries, our national productivity will be significantly enhanced.

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End-User Applications Software Laboratory (EASL)



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Thursday December 5, 1991

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- **Neural Network Software for Distortion-Invariant Object Recognition**
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